5.3 INDICATOR CONTAMINANTS IN MOBILE SEDIMENT

This section discusses mobile sediment at Portland Harbor by summarizing the sediment trap data collected for this investigation. The sediment trap investigation was designed to capture anticipated spatial and temporal variability of suspended sediment mass, fill data gaps related to the nature and extent of potential sources, and to support the preparation of the BERA ~~and the FS evaluations~~ (Anchor 2006c). The geographic locations of all sediment trap stations are presented on Map 2.1-24.

Discussion of the indicator contaminants addressed in this section focuses primarily on the following elements:

- A description of the data set for each contaminant, including frequency of detection and concentration range
- The sampling locations and periods (sampling quarters) with elevated contaminant concentrations and any apparent spatial or temporal gradients within the data set
- An evaluation of contaminant concentrations found in the Study Area compared to concentrations found at locations outside of the Study Area

The following subsections present tables, histograms, and other graphical summaries of the data to support discussion and evaluation of the nature and extent of the indicator contaminants in the sediment traps. Additional tabular and graphical summaries of the sediment trap data set are included in Appendix D2.

The chemistry distributions for the sediment traps are depicted graphic in histograms showing IC concentrations for each location and grouped by sampling quarter (Figures 5.3-6, 5.3-7, and 5.3-9 through 5.2-21). The blank spaces in the histograms within station groups signify that the volume of material collected for the quarter was not sufficient for analysis or the sediment trap was lost. Sample analyses resulting in non-detects are flagged in the histograms to distinguish them from cases where results are not available. Scales for IC concentrations (y-axis) were selected to emphasize higher concentrations yet visually distinguish comparatively low concentrations. In some cases, values above scale maximums are labeled with the sample concentration.

Other graphic displays used to assist with data interpretation include two scatter plots (Figures 5.3-3 and 5.3-8) with regression lines to fit the data and accompanying regression equations. Natural log-transformed PCB congener concentrations are regressed on natural log-transformed Aroclor concentrations in Figure 5.3-8 to display the relationship between PCB results obtained using different analytical methods. The relationship between sediment accumulation rates and the percentage of fines (i.e., silt and clay, particles ≤62 µm) is shown in a scatter plot of the un-transformed data sets (Figure 5.3-3). Plots of sample grain size distribution are shown in Figure 5.3-4. A line graph (Figure 5.3-1) is used to display the Willamette River daily discharge hydrograph

Commented [Int1]: A primary objective was supporting the FS alternative evaluation.

Commented [KK2R1]: While this is true, this is irrelevant to the discussion in this document. The sampling plan states the full objective.

Commented [Int3]: Moved to Appendix D.

Commented [Int4]: All data product numbering will need to checked as part of final RI editing to match the call out order.

Commented [A5]: This can be moved to Appendix D with all associated language removed from this section.

Commented [Int6]: The stacked bar graphs for PCBs, DDx, D/F, and PAHs provide important information and will be moved to Appendix D along with the associated text.

for the entire sediment trap sampling period, with quarterly sampling periods identified by different colors. This hydrograph also displays average historical daily discharges for a 36-year period (1972–2008). Figure 5.3-5 shows the quarterly distribution of the daily Willamette River discharge combined with sediment accumulation rates (also depicted in Figure 5.3-2), and percent fines (also depicted in Appendix D2.1, Figure D2.1-22).

5.3.1 Mobile Sediment Data Set

This section focuses on the concentrations of indicator contaminants associated with samples from in-river sediment trap samples collected within the Lower Willamette River. Sediment traps were deployed at 16 locations in the Lower Willamette River from late 2006 through late 2007 (see Map 2.1-2~~4-3~~). Twelve of the locations were within the Study Area between RM 1.9 and 11.5. One sediment trap was deployed just downstream of the Study Area at RM 1.8, two were located just upstream of Ross Island at RM 15.6 and 15.7, and one was located in Multnomah Channel. Paired sediment traps were deployed and maintained on opposite sides of the river at approximately RM 1.9, 6, 11.5, and 15.7. Samples were retrieved quarterly to obtain four quarters (1 year) of data. A total of 52 sediment trap samples were collected and analyzed per the protocols used in Rounds 2A and 2B; some samples were not obtained due to lack of material in the trap or loss of the trap.

In June 2009, seven sediment traps were deployed by the City of Portland between RM 11 and 12.1 (Map A??) to characterize settleable suspended sediments ~~deposited~~ in this area of the river during Quarters 3 and 4 of 2009 (GSI 2010). A total of 13 samples were collected and analyzed from this sampling event; one sediment trap (ST007) was not recovered during Quarter 4.

The samples were analyzed to measure the sediment trap mass accumulation and concentrations of sediment-bound contaminants that enter the Study Area from upstream sources, contaminant concentrations associated with regional sources within the Study Area, and concentrations of sediment-bound contaminants that migrate downstream from the Study Area. Additional information on the Lower Willamette River hydrology, sediment accumulation, and the role of fine sediments provided to aid with interpretation of the chemical data is presented in Figures 5.3-1 through 5.3-5. Distributions of the indicator contaminants are shown in Figures 5.3-6 through 5.3-21 and are summarized in Tables 5.3-1 through 5.3-7.

5.3.2 River Conditions During Sampling Events

Hydrologic data used to assess flow patterns during sampling were obtained from the USGS stream flow station located upstream of the Morrison Bridge (Willamette River at Portland, gage no. 14211720). The stream flows measured during the sampling events are presented in Figures 5.3-1a and b. The highest flows during sampling occurred during Quarter 1(November and December) of the 2006/2007 sampling event, with a median daily discharge of 79,000 cfs (Figure 5.3-1a). This period

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Commented [A8]: Make sure map reference is correct.

Commented [A9]: Put in correct reference to Map H2.3-1f-g that was moved to Appendix A.

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Commented [A11]: This is discussed in Section 5.1.

Commented [A12]: This information has been incorporated with the introduction to this section.

Commented [A13]: This is discussed in Section 2.

wascharacterized by variable flows, reaching twice the historical average discharge on a number of separate events. Lower than normal discharge periods (up to 60 percent of average) occurred twice during the month of December 2009, only to be followed by higher than normal flows (up to 50 percent of average) in early January 2010. The discharge record for Quarters 2 and 3 of the 2006/7 (March through August) sampling event (median discharges of 31,000 cfs and 10,000 cfs, respectively) did not demonstrate the variability that characterized Quarter 1 of the 2006/7 sampling event. In general, sampling during Quarters 2 and 3, and at least a portion of Quarter 4 of the 2006/7 sampling event and Quarter 3 of the 2009 sampling event (median discharge of 11,000 cfs), occurred during river flows that were very similar to historical averages. Discharge data from the last half of Quarter 4 of the 2006/7 sampling event (October 2007 through mid-November 2007) are considered estimates due to uncertainty about the accuracy of the rating curve used at the Portland location for flows less than 20,000 cfs.

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5.3.3 Rates of Sediment Accumulation

Net sediment accumulation rates at each station/quarter were calculated from the height of the sediment column in the traps and from the specific gravity and moisture content of the material. Sediment accumulation rates for each sediment trap are shown in Figures 5.3-2a and b. The highest rates of accumulation occurred during Quarter 1 of the 2006/7 sampling event, with the largest accumulation in the sediment traps placed at RM 11.3 and 15.6 (Figure 5.3-2a and b); sediment accumulation rates were lower in the sediment traps placed downstream of RM 11.3. Because~~Since~~ density measurements were only taken during the 2006/2007 sampling event, only that data was used to determine an average density of 1.22 g/cm^2/day to calculate accumulation rates for the 2009 sampling event (Figure 5.3-2b). ~~.~~ Traps were lost at stations ST014 (RM 7.5), ST006 (Swan Island Lagoon), and ST016 (RM 9.9) during Quarter 1 of the 2006/7 sampling event, so information regarding sediment accumulation is not available for these samples.

Medium-coarse silt made up approximately 50 percent of the trapped material during each quarter of the 2006/7 sampling event, although the highest sediment accumulation rates generally corresponded with a comparatively low percentage of fine material in the sediment traps. Grain size data are only available for one sediment trap sample (ST001) in Quarter 3 of the 2009 sampling event and six sediment traps (ST001 through ST006) in Quarter 4. Figure 5.3-3 shows rates of accumulation as a function of percent fines. Trend lines shown for the data set as a whole ($R^2 = 0.38$), as well as for the individual quarters (R^2 ranging from 0.0063 to 0.79), suggest inverse linear relationships between accumulation rates and percent fines for this data set are weak. TOC showed relatively small differences among samples with concentrations ranging from 1.1 to 3.5 percent. The majority of the measured TOC values, approximately 75 percent, range between 2 and 3 percent (Appendix D2.1, Figure D2.1-23).

Because sediment trap samples do not constitute temporally discrete samples (i.e., they represent a continuous collection over a three-month period), river conditions during sampling can only be discussed meaningfully in seasonal terms. Accumulation rates of trapped sediment may have been substantially affected by instantaneous events, such as high water resulting from heavy rainfall, but the impact of these isolated events cannot be quantified based on the existing data or the sampling methodology employed. Further, there were instances in which sediment traps were found to contain insufficient accumulated material for analysis were redeployed with the previous quarter's deposited material. In two cases (ST001 Quarter 3, and ST013 Quarter 3), traps retrieved in the following quarter were found to have a shorter column of sediment in them than they had when they were initially deployed (Table 5.3-1). In the case of ST013, a quarterly deposition rate of zero was used in Quarter 3 data presentations.

Figures 5.3-4a and b display the grain size distributions for all sediment trap samples analyzed. As shown, samples from each station generally showed similar grain size distributions, except for an increase in the coarse-grained fraction (i.e., sand) during the winter quarter (Quarter 1) at stations ST008, ST009, and ST010, and during the fall quarter (Quarter 4) at ST007 during the 2006/7 sampling event. Trends cannot be established for the trap data collected during the 2009 sampling event due to the lack of information in Quarter 3. The higher rate of sediment accumulation and the entrainment of sandy material in the sediment traps placed between RM 11.5 and 15.7 during Quarter 1 of the 2006/7 sampling event and Quarter 4 of the 2009 sampling event may be due in part to the frequency of higher flow events that occurred during this period (Figures 5.3-5a and b). The distribution of flows shows that the highest daily flows during 2006/7 Quarter 2 and 2009 Quarter 4 were approximately the same as median 2006/7 Quarter 1 flows. Approximately 75 percent of the 2006/7 Quarter 1 daily discharge levels were higher than any of those recorded during 2006/7 Quarters 3 and 4 and 2009 Quarter 3. A lower accumulation of trapped sediments, particularly at upriver stations, occurred during 2006/7 Quarters 3 and 4 and 2009 Quarter 3 when comparatively low-flow events were typical.

5.3.4 Total PCBs in Mobile Sediment

~~5.3.4.1 Total PCB Data Set~~

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PCB congener analysis was conducted for all 65 sediment trap samples; 60 of these samples were also analyzed for PCB Aroclors (Tables 5.3-2 through 7). PCB congeners were detected in all 52 samples, with total PCB congener concentrations ranging from 0.925 J µg/kg to 11,100 J µg/kg (Figures 5.3-6a and b). PCB Aroclors were detected in 41 of the 60 samples analyzed, with total Aroclor concentrations ranging from 3.1 U µg/kg to 2,600 µg/kg (Figure 5.2-7a and b).

The relationship between total PCB congener and total PCB Aroclor concentrations is shown in Figure 5.3-8 and discussed in detail in Appendix D1.5. The sediment trap correlation between paired congener and Aroclor totals is r^2=0.7. Although the PCB concentrations in sediment trap samples correlated well for the two methods, concentrations of total PCBs measured as congeners were higher overall than total

PCBs measured as Aroclors. The methods used for analysis of PCB congeners and Aroclors are fundamentally different and would be expected to yield moderate differences in total PCB concentrations, as described in Appendix D1.5. In addition, among detected Aroclor results for the sediment trap samples about one third of the individual concentrations (19 of 60 results) were below the method reporting limit (MRL).

~~5.3.4.2~~5.3.4.1 Total PCB Spatial and Temporal Evaluation in Study Area

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The PCB concentrations varied by three orders of magnitude throughout the site. PCB congener concentrations were the highest in sediment traps located in the vicinity of RM 11.3E (ST007 measured in 2006/7 and ST003 measured in 2009) compared to other locations (Figures 5.3-6a and b). The greatest sample concentration (11,100 ug/kg) was measured in the fourth quarter of 2007. PCB concentrations at Station ST007 during low- and medium-flow periods (Quarters 2, 3 and 4) were elevated two to three orders of magnitude above concentrations at other locations for the respective periods. Other significant peaks are noted in 2009 at ST001 and ST002 just downstream of ST003, and in 2007 offshore of Fireboat Cove (ST015; RM 9.7W), in Swan Island Lagoon (ST006), and in Willamette Cove (ST013; RM 6.7E). PCB Aroclors show the same notable peaks at ST013, ST006, and ST007 (2006/7 data set) and ST003 (2009 data set) as shown in Figures 5.3-7a and b.

During the 2006/2007 sampling event, increasing concentrations generally occurred with each successive period at all stations except ST002 (RM 1.8W) and ST011 (RM 3.5 E), a trend that was clear in the PCB congener data but not apparent for Aroclors. The lack of an apparent trend with Aroclors is possibly due to higher detection limits for Aroclors resulting in a lower number of samples with detectable Aroclor concentrations. The 2009 data set shows the same temporal pattern as Quarter 3 of this data set corresponds to Quarter 4 of the 2006/7 data set and Quarter 3 corresponds to Quarter 1 of the 2006/7 data set.

Figures 5.3-6a and 5.3-7a show~~s~~ that concentrations in sediment traps are generally greater on the eastern shore of the river than the western shore. Concentrations also are greatest in sediment traps deployed at the upper end of the study area and show an apparent decreasing pattern in the downstream direction. There are two major exceptions to this observation at the upper end of the study area. The first is the sequence of sediment traps in the eastern nearshore area from RMs 11.3, 9.9, and 6.7 (ST007, ST006, and ST013) where the concentrations go from extremely high, to extremely low and then peak again before gradually decreasing through the study area. Conversely, the sequence of sediment traps in the western nearshore area from RMs 11.5, 9.7, and 7.5 (ST008, ST015, and ST014) show that the concentration go from extremely low, to extremely high, and then show a decreasing pattern through the study area. Both Aroclors and PCB congeners show these patterns.

The 2009 data is limited to the eastern nearshore area from RM 11.1 to 12.2. These sediment traps show that concentrations are generally the same in the upper river traps

(ST007, ST006 and ST005) and then increase in trap ST004 before spiking in trap ST003 and then decreasing in ST002 and ST001. This pattern seems to show that there is either a lateral and/or a bedded sediment source of elevated PCBs in the vicinity of ST004 and ST003 that is influencing the concentration of the mobile sediments in th~~e~~ose traps and the traps immediately downstream (ST002 and ST001). Both Aroclors and PCB congeners show this pattern.

It is also observed that the lowest concentrations were observed during the higher river flows (Figure 5.3-1a-b and 5.3-5) in Quarters 1 and 2; however, this period had the most accumulation in the traps (Figure 5.3-2a) suggesting that localized suspended sediments with elevated PCBs levels are diluted by inputs of cleaner suspended sediment deposited during river higher flows. During the summer period (Quarter 3), the river flows and sediment accumulation are the lowest, but the concentrations were the second highest. This observation suggests more influence of the localized elevated levels on the material being deposited in the traps during low flows. ~~.~~The highest concentrations occurred when the river flows transitioned from low flow and were beginning to increase due to increasing storm events (late summer into fall)~~,~~ ~~suggesting t~~The accumulation in the traps during this time period is still quite low ~~indicating~~ suggesting that this is the period when the highest relative percentage of the more contaminated sediment ~~-~~is being mobilized.

~~5.3.4.3~~5.3.4.2 Total PCB Relationship by River Reach

Total PCB congener concentrations in the Study Area samples were all higher than the average PCB concentrations from upstream locations (ST009 and ST010)—one-to-five fold greater than upstream concentrations, in most cases. These trends were generally also reflected in the Aroclor data. The downstream total PCB concentrations (ST001 and ST002) are generally the same as the concentrations observed in Multnomah Channel (ST003) and seem to be approaching upriver concentrations, although the total PCB congener concentrations are about two fold higher. The concentrations entering the site, at least in the eastern nearshore region (ST005, ST006 and ST007 of the 2009 data set) are similar in concentration to the upriver sediment traps (ST009 and ST010) indicating that for the time periods measured, the downtown reach has little to no influence on the incoming depositional sediment concentrations.

5.3.5 Total PCDD/Fs and TCDD TEQs in Mobile Sediment

5.3.5.1 Total PCDD/Fs and TCDD TEQs Data Set

Total PCDD/Fs and TCDD TEQ analysis was conducted for 60 sediment trap samples (Tables 5.3-2 through 7). Total PCDD/ were detected in all 60 samples, with total PCDD/F concentrations ranging from 5.16 J pg/g to 6,100 pg/g. TCDD TEQs were also detected in all 60 samples analyzed, with concentrations ranging from 0.0529 J pg/g to 16.3 J pg/g.

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Commented [Int21]: Proposed revisions to improve clarity

Commented [Int22]: Figure 5.3-6b shows higher concentrations in Q3 than Q4, suggest that during low flow, there is a DT reach input relative to upriver, so this statement is not supported. Propose deleting it rather than drawing a conclusion here given the limited data set.

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5.3.5.2 Total PCDD/FsSpatial and Temporal Evaluation in Study Area

The highest total PCDD/F concentration (6,100 J pg/g) occurred during Quarter 4 of the 2006/7 sampling event at ST006 (Swan Island Lagoon) (Figures 5.3-9a and b). This sample was elevated 1 to 2 orders of magnitude above concentrations at most other locations. However, a temporal evaluation of PCDD/Fs at ST006 could not be conducted as no samples from previous quarters were analyzed for total PCDD/Fs at this location. Additional total PCDD/F peaks of 1,820 J pg/g and 1,250 J pg/g occurred during Quarter 3 of the 2006/7 sampling event at ST007 (RM 11.3E) and at ST002 (RM 1.8W), respectively. Relatively high concentrations were also seen in Quarter 4 samples of the 2006/7 sampling event in traps ST014 (RM 7.5W; 1,060 J pg/g) and ST007 (745 J pg/g), and Quarter 1 samples of the 2006/7 sampling event in traps ST001 (RM 1.9E; 563 pg/g) and ST011 (RM 3.5E; 535 pg/g).

Total PCDD/F concentrations were greatest in Quarter 3 of the 2009 data set with the highest concentration (1,640 pg/g) in sediment trap ST001 at RM 11.1 followed by traps ST004 (RM 11.6; 1,280 pg/g), ST003 (RM 11.4; 1,120 pg/g), and ST006 (RM 11.9; 900 pg/g). Relatively high concentrations were also seen in Quarter 4 of the 2009 sampling event in trap ST005 (RM 11.8; 879 J pg/g). The ~~temporal pattern in the 2009 data set indicates that~~ lower flow period (Quarter 3) concentrations in the 2009 data set are consistently greater than the higher flow period (Quarter 4) concentrations, suggesting ~~the dilution of localized elevated suspended sediment levels by less contaminated suspended sediments entering the system in Quarter 4. which would mean~~ that the concentration at ST005 during ~~this period~~Quarter 3 may have had the greatest sample concentration in this area.

Samples collected in the 2006/2007 sampling event with total PCDD/F concentrations greater than 500 pg/g are observed in ST001 (RM 1.9E) and ST011 (RM 3.5E) during Quarter 1; ST002 (RM 1.8W) and ST007 (RM 11.3E) during Quarter 3; and ST014 (RM 7.5W), ST006 (Swan Island Lagoon), and ST007 (RM 11.3E) during Quarter 4.

There is no ~~apparent~~ consistent spatial gradient or trend in total PCDD/F concentrations throughout the river indicating that concentrations measured in sediment traps are more representative of localized sediments. The highest PCDD/F concentrations among stations generally occurred during Quarters 4 and 3. Stations ST007 and ST009 in the eastern nearshore zone at RM 11 and 15 contained higher total PCDD/Fs than ST008 and ST010 placed at similar river miles in the western nearshore zone throughout the 2006/2007 sampling period. These results indicate that solids collected in the traps in this portion of the river in part reflect localized inputs specific to the eastern or western nearshore zones rather than being representative of river-wide mobile sediments.

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5.3.5.3 TCDD TEQ Spatial and Temporal Evaluation in Study Area

The highest TCDD TEQ was found in the Quarter 4 sample of the 2006/7 sampling event in trap ST006 (Swan Island Lagoon) (Figure 5.2-10a and b). Like total PCDD/Fs, Quarter 4 was the only time TCDD TEQ were analyzed at this location so it is difficult to gauge the occurrence of similar TCDD TEQ concentrations during other periods.

TCDD TEQs greater than 1 pg/g were measured during the 2006/7 sampling event at ST001 (RM 1.9E), ST011 (RM 3.5E), and ST005 (RM 6.0W) during Quarter 1; ST002 (RM 6.0W during Quarter 2; ST002 (RM 1.8W) and ST007 (RM 11.3E) during Quarter 3; and ST014 (RM 7.5W), ST006 (Swan Island Lagoon), ST007 (11.3E). During Quarter 3 of the 2009 sampling event, TCDD TEQ values greater than 1 pg/g occurred in all sediment traps except ST002 and were not analyzed in ST005. TCDD TEQ values greater than 1 were also present in Quarter 4 of the 2009 sampling event in traps ST004 and ST0005. TCDD TEQ spatial and temporal patterns were similar to total PCDD/F patterns.

5.3.5.4 Total PCDD/F and TCDD TEQ Relationship by River Reach

Study Area locations generally had total PCDD/F and TCDD TEQ concentrations higher than concentrations from the upstream locations. However, total PCDD/F and TCDD TEQ concentrations from the two upstream locations were not similar to each other, with concentrations from ST009 (RM 15.7E) averaging more than six times those from ST010 (RM 15.6W). Some ST009 samples had comparatively higher total PCDD/F and TCDD TEQ concentrations than concurrently sampled Study Area locations during the same quarters (Figures 5.3-9a and 5.3-10a).

Total PCDD/F and TCDD TEQ concentrations in the downstream reach were elevated above the upriver sediment traps (ST009 and ST010) at ST001 (RM 1.9E), ST002 (RM 1.8W). Total PCDD/Fs and TCDD TEQ in the study area reach were also elevated above the upriver traps at traps ST011 (RM 3.5E), ST014 (RM 7.5W), ST006 (Swan Island Lagoon), and ST007 (RM 11.3E). Total PCDD/Fs in the study area were also elevated above the upriver traps at ST005 (RM 6.0W).

Total PCDD/F concentrations downstream of the study area were greater in Multnomah Channel (ST003) during Quarter 4 of the 2006/7 sampling event than in the lower study area (RM 3.5 to 7.5). TCDD TEQ concentrations were also elevated in this sample. Mobile sediments were also greater downstream at ST002 (RM 1.8W) during Quarter 3 of the 2006/7 sampling event than anywhere else below RM 11.3E (ST007) in the main channel and at ST001 (RM 1.9E) during Quarter 1 of the 2006/2007 sampling event than anywhere in the main channel of the study area.

5.3.6 Total DDx in Mobile Sediment

5.3.6.1 Total DDx Data Set

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Total DDx analysis was conducted for 63 sediment trap samples (Tables 5.3-2 through 7). DDx compounds were detected in all but two sediment trap samples. Concentrations of total DDx ranged from 0.69 µg/kg to 150 µg/kg in samples with detectable concentrations.

5.3.6.2 Total DDx Spatial and Temporal Evaluation in Study Area

The highest total DDx concentration (150 ug/kg) occurred during Quarter 4 of the 2006/7 sampling event at ST007 (RM 11.3E) and was approximately five times higher than the next highest sample. Total DDx concentrations greater than 10 ug/kg are observed in sediment traps ST007 (RM 11.3E), ST006 (Swan Island Lagoon), ST011 (RM 3.5E), abd ST014 (RM 7.5W) during Quarter 3 of the 2006/7 sampling event. During Quarter 4 of the 2006/7 sampling event, peak total DDx concentrations are observed in traps ST007 (RM 11.3E), ST006 (Swan Island Lagoon), ST004 (RM 6.0E), ST015 (RM 9.7W), ST014 (RM 7.5W), ST005 (RM 6.0W), and ST012 (RM 4.5W). Total DDx concentrations greater than 10 ug/kg occurred in the 2009 sampling event in trap ST001 (RM 11.1) during the third quarter and trap ST003 (RM 11.4) during Quarters 3 and 4.

At most locations in 2006/7, total DDx concentrations were highest during Quarter 4 from mid-August to mid-November. In 2009, total DDx concentrations were also highest during Quarter 4, although the ~~Quarter 4~~ time frame was mid-September to mid-January for that sampling event (Figures 5.3-11a-b). However, both Quarter 4 sampling events caught the rising limb of the hydrograph (Figure 5.3-1a-b), suggesting elevated levels of total DDx on suspended sediments enter the river system during periods of increasing precipitation ~~the transistion to the rainy season~~. The spatial patterns of sediment trap data from the Study Area indicate inputs of elevated total DDx sediment at RM 11.3 E and at RM 6 E, which may also be the downstream deposition of sediments from RM 11.3. Elevated levels of total DDx in suspended sediments are also observed in Swan Island Lagoon. In the western nearshore zone, elevated concentrations are evident at RM 6.0 W and 7.5 W. Less prominent elevated concentrations are observed at RM 9.7 W and 4.5 W.

Patterns of relative concentrations of DDx constituents among samples are somewhat confounded by elevated detection limits and interferences. Detection limits were elevated in 18 percent of the samples, and another four percent were classified as non-detects due to contamination in the associated laboratory or field blanks (Anchor and Integral 2008). The elevated detection limits could obscure low concentrations of DDx. In addition, 9 percent of the results were qualified as tentatively identified and estimated (NJ) during data validation due to poor confirmation, and another 15 percent were estimated (J) as a result of the confirmation data.

5.3.6.3 Total DDx Relationship by River Reach

Total DDx concentrations in Study Area samples were generally higher than those from upstream locations. Overall, 24 of the 63 (38 percent) Study Area samples had higher total DDx concentrations than the maximum concentration from upstream samples. Differences between Study Area and upstream samples were most pronounced during Quarters 3 and 4 of both the 2006/7 and 2009 sampling events. By contrast, Study Area samples from the first two quarters had total DDx concentrations that are only nominally higher than the concentrations observed in the upstream samples.

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Integral: Yes, this is the sed trap data report

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Concentrations of total DDx in the downstream reach at ST001 (RM 1.9E) were elevated above the upriver sediment traps (ST009 and ST010); however, ST002 (RM 1.8W) concentrations seemed consistent with the upriver concentrations. Total DDx in all the study area reach traps were also elevated above the upriver traps except traps ST016 (RM 9.9E) and ST013 (RM 6.7E).

Total DDx concentrations downstream of the study area were lower or about the same in Multnomah Channel (ST003) during the 2006/7 sampling event than in the study area. Mobile sediments were also lower downstream at ST002 (RM 1.8W) than at ST001 (RM 1.9E) or ST003 (Multnomah Channel).

5.3.7 Total PAHs in Mobile Sediment

5.3.7.1 Total PAH Data Set

Total PAH analysis was conducted for 62~~3~~ sediment trap samples (Tables 5.3-2 through 7). PAHs were detected in all samples analyzed, with concentrations of total PAHs ranging from 77 J µg/kg to 11,000 µg/kg.

5.3.7.2 Total PAH Spatial and Temporal Evaluation in Study Area

The PAH concentrations varied by over two orders of magnitude throughout the site. Total PAH concentrations were the highest in sediment traps located in the vicinity of RM 6.0W (ST005 measured in 2006/7) compared to other locations (Figures 5.3-12a and b). The highest concentration (11,000 ug/kg) was measured in the fourth quarter of 2007. Other elevated levels (greater than or equal to 1,000 ug/kg) are noted in 2007 at ST006 (Swan Island Lagoon), ST014 (RM 7.5W), ST004 (RM 6.0E), ST011 (RM 3.7E), ST014 (RM 7.5W), ST012 (RM 4.5W), and in 2009 at ST001 and ST003 within RM 11E.

During the 2006/2007 sampling event, the highest PAH concentrations within stations tended to occur during Quarters 3 and 4, but additional seasonal differences among stations were not apparent. The lack of an apparent trend is possibly due to the lack of samples collected for every quarter at all stations. The 2009 data set also shows the lack of a trend where some samples are greater in Quarter 3 while others are greater in Quarter 4.

Figure 5.3-12a shows that concentrations in sediment traps are generally greater on the western shore of the river than the eastern shore. Concentrations also are greatest in sediment traps deployed at the middle of the study area and are generally higher downstream of this area compared with upstream.

The 2009 data is limited to the eastern nearshore area from RM 11.1 to 12.2. These sediment traps show that concentrations vary throughout the area. This pattern seems to show that there may be ~~several sources of~~localized sediment contamination that is influencing the concentration of the mobile sediments in this area.

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Commented [Int39]: See Fgiure 5.3-12a

Commented [Int40]: Propose deleting this source statement, range of values is not great in these small area

It is also observed that the lowest concentrations were observed during the higher river flows (Figure 5.3-1a-b and 5.3-5) in Quarters 1 and 2 of the 2006/7 sampling event; however, this period had the most accumulation in the traps (Figure 5.3-2a) suggesting that localized inputs are diluted by the larger volume of cleaner material being transported and deposited during higher river flows. During the summer period (Quarter 3), the river flows and sediment accumulation are the lowest, but the concentrations were the second highest. This pattern suggests that there is more localized influence on the material being deposited during low flow periods. The highest concentrations occurred when the river flows transitioned from low flow and were beginning to increase due to increasing storm events (late summer into fall). However, the accumulation in the traps during this time period is still quite low suggesting that this is the period when more contaminated sediments are being mobilized in (resuspended bed material) and adjacent (e.g., stormwater discharge) to the site.

Commented [Int41]: Proposed revision

5.3.7.3 Total PAH Relationship by River Reach

Total PAH concentrations were greater upriver in ST010 (RM 15.6W) during Quarter 1 of the 2006/7 sampling event than all other samples, except ST005 (RM 6.0W). Overall, 32 of the 34 (94 percent) Study Area samples had total PAH concentrations higher than concurrent samples from upstream locations, with the exception of Quarter 1, where the total PAH concentration of upstream sample ST010 (1,300 µg/kg) was higher than all but one Study Area sample (ST005). Generally, concentrations in the Study Area were within an order of magnitude of the upriver concentrations, with the exception of samples collected at ST005 (RM 6.0W) where concentrations were up to 40 times the upriver concentrations.

Samples in the upper reaches (RM 8 to 11.8) of the Study Area are consistent with samples collected upriver, although the 2009 data indicate that there are relatively high PAH levels in the vicinity of RM 11E. The 2009 data also show that there is variability in localized areas of the site (Figure 5.3-12b) with concentrations ranging over by a factor of five within the river mile. The downstream total PAH concentrations (ST001 and ST002) range from about two to four fold higher than the upriver concentrations. In general, total PAH concentrations were higher at locations between RM 3 and 6, including Multnomah Channel (ST003) which had a relatively high Quarter 4 level (2,300 J µg/kg) than in other sampled locations (Figure 5.3-12a).

Commented [Int42]: 1220 to 255 ppb

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5.3.8 Bis(2-ethylhexyl)phthalate in Mobile Sediment

5.3.8.1 BEHP Data Set

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BEHP analysis was conducted for 61~~56~~ sediment trap samples (Tables 5.3-2 through 7). BEHP was detected in all samples analyzed at concentrations ranging from 35 µg/kg to 1,600 µg/kg.

5.3.8.2 BEHP Spatial and Temporal Evaluation in Study Area

BEHP concentrations varied by two orders of magnitude throughout the site. BEHP concentrations were greatest during Quarters 3 and 4 of the 2006/7 sampling event

(1,600 ug/kg and 710 ug/kg) at ST006 (Swan Island Lagoon), although samples were not analyzed at ST006 during Quarters 1 and 2 (Figure 5.3-13a). High concentrations were also noted at ST007 (RM 11.3E) during Quarters 2, 3 and 4 and ST015 (RM 9.7W) during Quarter 4. Concentrations throughout the site were generally less than 250 ug/kg, except as noted above, and varied most during Quarter 4 of the 2006/7 sampling event with values ranging by a factor of 4 (excluding the high concentrations noted above). There is no observable spatial or temporal trend in the concentrations of BEHP throughout the site.

Concentrations measured in the 2009 sampling event (Tables 5.3-6 and 7; Figure 5.3-13b) reveal that concentrations in localized areas of the site vary widely. Concentrations in Quarter 3 varied by a factor of five, while concentrations in Quarter 4 varied by a factor of three. Relatively high concentrations (greater than 250 ug/kg) are noted in ST002, ST006, and ST007 during Quarter 3 and ST001, ST002, ST003, ST005, and ST006 during Quarter 4.

5.3.8.3 BEHP Relationship by River Reach

Upstream BEHP concentrations at ST009 (RM 15.7E) and ST010 (RM 15.6W) were generally lower than Study Area locations during concurrent sampling. During Quarter 4, however, the BEHP concentration at ST010 (480 J µg/kg) was higher than at all Study Area locations except ST006 (Figure 5.3-13a). Quarter 3 also showed higher upriver concentration in ST009 (210 ug/kg) than at ST004 (81 ug/kg) and ST012 (150 ug/kg).

Concentrations in the downstream traps (ST001 and ST002) and in Multnomah Channel (ST003) were lower than concurrent Study Area traps. In Quarters 1 and 2, the downstream traps show that mobile concentrations were at or approaching upriver concentrations. During Quarters 3 and 4, the downstream traps had lower concentrations than the upriver traps.

5.3.9 Total Chlordanes in Mobile Sediment

5.3.9.1 Total Chlordanes Data Set

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One or more chlordanes were detected in 36 of the 63 samples analyzed (Tables 5.3-2 through 7). Detectable concentrations of total chlordanes ranged from 0.22 J to 3.7 NJ µg/kg. Extemely high reporting limits for non-detects are noted in trap ST007 during Quarters 3 and 4 of the 2006/7 sampling event (98 and 460 µg/kg, respectively) and in trap ST003 during Quarter 4 of the 2009 sampling event (86 ug/kg). Detection limits were also notably high in traps ST001 and ST003 during Quarter 3 of the 2009 sampling event (3.2 and 4.3 ug/kg, respectively). These elevated NDs appear to be due to matrix interferences. These samples all had relatively high PCBs levels which may have interfered with the pesticide quantification.

5.3.9.2 Total Chlordanes Spatial and Temporal Evaluation in Study Area

The highest detected total chlordanes concentration was found at ST008 (RM 11.5W) during Quarter 1 (Figures 5.3-14a-b). Other comparatively high detected concentrations (>3 µg/kg) were found during Quarter 4 at ST011 (RM 3.5E) and during Quarter 3 at ST006 (Swan Island Lagoon). Total chlordane concentrations were highly variable within and among locations and within and among seasons. Higher concentrations were noted in Quarters 1, 3 and 4 of the 2006/7 sampling event than in Quarter 2. Although west-side samples had higher levels during Quarter 1 than east-side sediment traps, variations in data were difficult to assess due to the number of non-detects and the vast range of reporting limits. Therefore, spatial and seasonal gradients or trends were not apparent.

5.3.9.3 Total Chlordanes Relationship by River Reach

Overall, Study Area total chlordane concentrations were higher than upstream concentrations. The maximum total chlordanes in upstream samples was 1 NJ µg/kg, whereas nine of the 14 Study Area stations had at least one sample with greater than 1 µg/kg total chlordanes. Only one downstream sample in ST002 had a concentration greater than 1 ug/kg.

5.3.10 Aldrin and Dieldrin in Mobile Sediment

5.3.10.1 Aldrin and Dieldrin Data Sets

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Aldrin and dieldrin, two closely related organochlorine pesticides, were analyzed in 63 samples. Aldrin was detected in seven samples and dieldrin was detected in six samples (Tables 5.3-2 through 7). Only one of the samples analyzed contained detectable levels of both aldrin and dieldrin for the same sample (the 2009 Quarter 4 sample at ST004 (RM 11.5E). Extemely high reporting limits for non-detects are noted in trap ST008 during Quarter 1 of the 2006/7 sampling event for both aldrin and dieldrin (1.6 and 3 µg/kg, respectively), traps ST004 and ST007 during Quarter 3 of the 2006/7 sampling event for dieldrin (1.1 and 13 ug/kg), and in trap ST006 during Quarter 4 of the 2006/7 sampling event (1.2 ug/kg). All other non-detected values were less than 1 ug/kg.

The detected concentrations of aldrin ranged from 0.11 J µg/kg to 1.1 NJ µg/kg (Figures 5.3-15a-b), with the highest concentration found at Station ST005 (RM 6W). Two of the detected aldrin samples were at downstream locations ST001 (RM 1.9E) and ST003 (Multnomah Channel). Detected dieldrin concentrations were more variable (Figures 5.3-16a-b), with concentrations ranging from 0.15 NJ µg/kg to a maximum of 4.9 µg/kg at ST006 (Swan Island Lagoon). Two of the six dieldrin detections were at the upstream location ST009 (RM 15.7E) and one was downstream at ST003 (in Multnomah Channel).

5.3.10.2 Aldrin and Dieldrin Spatial and Temporal Evaluation in Study Area

There were five detected values for aldrin within the Study Area. Two aldrin detections occurred during Quarter 1 of the 2006/7 sampling event at ST005 (6.0W) and ST012

(4.5 W), one detection occurred during Quarter 4 of the 2006/7 sampling event at ST014 (7.5W), and two detections occurred during Quarter 4 of the 2009 sampling event at ST002 (RM 11.1E) and ST004 (RM 11.5E).

There were three detectable dieldrin concentrations within the Study Area. Two were measured during Quarter 3 of the 2006/7 sampling event at ST006 (Swan Island Lagoon) and ST011 (RM 3.5E), and one was measured in Quarter 4 of 2009 at ST004 (RM 11.5E).

The infrequency of detections did not allow for assessment of a possible geographical concentration gradient or trend. However, detected aldrin concentrations occurred primarily at or below RM 7.5 in the western nearshore zone, while dieldrin was detected primarily in the eastern nearshore zone.

5.3.10.3 Aldrin and Dieldrin Relationship by River Reach

Aldrin was not detected in upriver samples, but was detected in two downstream samples, ST001 (RM 1.9E) and ST003 (Multnomah Channel) during Quarter 1 of the 2006/7 sampling event. Dieldrin was detected upriver at ST009 (RM 15.7E) during both Quarters 3 and 4 of the 2006/7 sampling event, but was only detected downstream at ST003 (Multnomah Channel) during Quarter 4. There was not enough data to determine any relationship for aldrin and dieldrin between river reaches.

5.3.11 Arsenic in Mobile Sediment

5.3.11.1 Arsenic Data Set

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Arsenic was detected in all 62 samples analyzed at concentrations ranging from 1.48 J mg/kg to 7.01 mg/kg (Tables 5.3-2 through 7).

5.3.11.2 Arsenic Spatial and Temporal Evaluation in Study Area

There was relatively little variation in concentrations among samples within the Study Area, with values ranging between 2.75 mg/kg and 7.01 mg/kg (Figures 5.3-18a-b). The highest arsenic concentration was found at Station ST011 (RM 3.5E) during Quarter 4 of the 2006/7 sampling event. The highest levels were generally found during Quarter 4, particularly downstream of RM 9, although Quarter 2 showed equally high levels in the upper Study Area (RMs 9.7-11.5).

5.3.11.3 Arsenic Relationship by River Reach

Most concentrations of arsenic from Study Area stations were similar to or slightly above arsenic concentrations in upriver locations. Arsenic levels in Study Area samples rarely varied from the arsenic levels at upstream stations by more than a factor of two. Downstream samples had similar concentrations to those in the Study Area, and were also generally greater than the upriver samples by a factor of two.

5.3.12 Chromium in Mobile Sediment

5.3.12.1 Chromium Data Set

Chromium was detected in all 62 samples analyzed at concentrations ranging from 1~~0~~6.8 J mg/kg to 59.5 mg/kg (Tables 5.3-2 through 7).

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5.3.12.2 Chromium Spatial and Temporal Evaluation in Study Area

There was relatively little variation in concentrations among samples within the Study Area, with values ranging between 16.8 mg/kg and 47.1 mg/kg (Figures 5.3-19a-b). The highest chromium concentration in the Study Area was found during Quarter 1 of the 2006/7 sampling event at Station ST013 (RM 6.7E). The highest concentrations within stations also tended to occur during Quarter 1. The only other sample collected within the Study Area greater than 40 mg/kg was at ST006 (Swan Island Lagoon) during Quarter 3 of the 2006/7 sampling event. The majority of the 2009 data set had concentrations less than 30 mg/kg. There were no locations with levels of chromium consistently higher than all others, and there was little variability between samples collected on either shore of the river.

5.3.12.3 Chromium Relationship by River Reach

Although the highest chromium concentration was found in ST009 (RM 15.7E) in the upriver reach during Quarter 3 of the 2006/7 sampling event, the majority of samples in this reach range between 30 and 40 mg/kg. Likewise, most chromium concentrations from Study Area stations were within the range of samples typically found in the upriver reach. Downstream samples ranged from 16.8 J mg/kg to 40.4 mg/kg with the majority of values also typically within the 30-40 mg/kg range.

5.3.13 Copper in Mobile Sediment

5.3.13.1 Copper Data Set

Copper was detected in all 62 samples analyzed at concentrations ranging from 15.2 mg/kg to 93.6 mg/kg (Tables 5.3-2 through 7). There was relatively little variation in concentrations among samples, with the majority of the values within a factor of 3.

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5.3.13.2 Copper Spatial and Temporal Evaluation in Study Area

The highest copper concentration was found at Station ST006 (Swan Island Lagoon) during Quarter 3 of the 2006/7 sampling event (Figures 5.3-20a-b). The highest concentrations among sampling periods per station often occurred during Quarter 4 of the 2006/7 sampling event, particularly at stations from RM 3.5 through 6.7. The majority of samples collected in Quarter 4 were greater than 50 mg/kg, while the majority of samples collected in other Quarters were generally between 30 and 50 mg/kg. All samples collected during the 2009 sampling event were less than 4~~3~~2.~~7~~ mg/kg. Samples greater than 50 mg/kg are noted from the 2006/7 sampling event during Quarter 1 at ST013 (RM 6.7E), during Quarter 2 at ST004 (RM 6.0E) and ST013 (RM 6.7E), during Quarter 3 at ST006 (Swan Island Lagoon) and ST011 (RM 3.5E), and during Quarter 4 at ST004 (RM 6.0E), ST005 (RM 6.0W), ST006 (Swan Island

Lagoon), ST007 (RM 11.3E), ST011 (RM 3.5E), ST012 (RM 4.5W), and ST013 (RM 6.7E).

5.3.13.3 Copper Relationship by River Reach

Although the second highest copper concentration was found in a sample from one of the upstream locations (ST009) during Quarter 3 of the 2006/7 sampling event, the majority of samples in this reach are less than 43 mg/kg. Most copper concentrations from Study Area stations were slightly above upriver copper concentrations collected during the same time period, except during Quarter 3, as mentioned above. Copper levels in Study Area samples rarely varied from the copper levels at upstream stations by more than a factor of two. Downstream samples ranged from 25.1 mg/kg to 52.4 mg/kg, which is similar to the majority of samples measured in the Study Area.

5.3.14 Zinc in Mobile Sediment

5.3.14.1 Zinc Data Set

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Zinc was detected in all 62 samples analyzed at concentrations ranging from 71.5 mg/kg to 319 mg/kg (Tables 5.3-2 through 7). There was relatively little variation in concentrations among samples, with concentrations being within a factor of 3.

5.3.14.2 Zinc Spatial and Temporal Evaluation in Study Area

The highest zinc concentration was found during Quarter 3 of the 2006/7 sampling event at Station ST006 (Swan Island Lagoon). ST006 was the only station that appeared to contain comparatively high localized concentrations, although only data from two quarters were available from this location. Among sampling periods (Figures 5.3-20a-b), the highest zinc concentrations per station most often occurred during Quarter 4 of the 2006/7 sampling event. Quarter 4 of the 2009 sampling event generally had the lowest zinc levels among sampling periods. The majority of samples collected were less than 140 mg/kg. Samples greater than 140 mg/kg are noted from the 2006/7 sampling event during Quarter 2 at ST015 (RM 9.7W), during Quarter 3 at ST006 (Swan Island Lagoon) and ST011 (RM 3.5E), and during Quarter 4 at ST004 (RM 6.0E), ST005 (RM 6.0W), ST006 (Swan Island Lagoon), ST007 (RM 11.3E), ST011 (RM 3.5E), ST012 (RM 4.5W), ST013 (RM 6.7E), ST015 (RM 9.7W) and ST016 (RM 9.9E).

5.3.14.3 Zinc Relationship by River Reach

Most concentrations of zinc from Study Area stations were slightly above zinc concentrations in upriver locations, except during Quarter 3 of the 2006/7 sampling event. Zinc levels in Study Area samples rarely varied from the zinc levels at upstream stations by more than a factor of two during the same sampling period. Downstream samples ranged from 101 mg/kg to 160 mg/kg, with higher concentrations in downstream stations ST001 and ST002 during Quarter 4 of the 2006/7 sampling event. Samples collected downstream during Quarters 1, 2 and 3 and those collected in Multnomah channel are similar to the majority of samples measured in the Study Area, but slightly higher than upriver samples.

5.3.15 Tributyltin Ion in Mobile Sediment

5.3.15.1 TBT Data Set

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TBT analysis was conducted for 60 sediment trap samples (Tables 5.3-2 through 7). TBT was detected in 46 of the samples analyzed with detectable concentrations of TBT ranging from 0.48 J µg/kg to 81 µg/kg.

5.3.15.2 TBT Spatial and Temporal Evaluation in Study Area

TBT concentrations at ST006 (Swan Island Lagoon) during Quarters 3 and 4 of the 2006/7 sampling event, the only two quarters that data were available for that station, and at ST001 during Quarter 3 of the 2009 data set were elevated an order of magnitude above other locations (Figures 5.3-21a-b). Concentrations within locations were generally highest during Quarter 4, and concentrations during all sampling periods were generally highest downstream of Swan Island Lagoon. The majority of samples collected were less than 5 mg/kg. Samples greater than 5 mg/kg are noted from the 2006/7 sampling event during Quarter 3 at ST004 (RM 6.0E), ST006 (Swan Island Lagoon), and ST014 (RM 7.5W, and during Quarter 4 at ST005 (RM 6.0W), ST006 (Swan Island Lagoon), ST007 (RM 11.3E), ST011 (RM 3.5E), and ST014 (RM 7.5W). The only sample greater than 5 mg/kg during the 2009 sampling event was during Quarter 3 at ST001 (RM 11.1).

5.3.15.3 TBT Relationship by River Reach

There was only one sample out of six in the upriver reach that was detected; the detected concentration was 1.9 mg/kg. All non-detect values in the upriver reach were below this value. In general, TBT levels in the Study Area were higher than TBT level detected in the upriver reach. However, since only one of six samples from the upriver stations had a detectable TBT concentration, the degree of elevation over upstream concentrations~~levels~~ cannot be meaningfully quantified. Concentrations of TBT in the downstream reach were generally less than 4.3 mg/kg, with only one sample greater than 5 mg/kg noted during Quarter 3 at ST002 (RM 1.8W). Downstream TBT samples are notably less than the Study Area, but greater than the upriver reach.